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Multi Wiring Board technology for next generation high speed application

Hitachi Chemical
Working On Wonders

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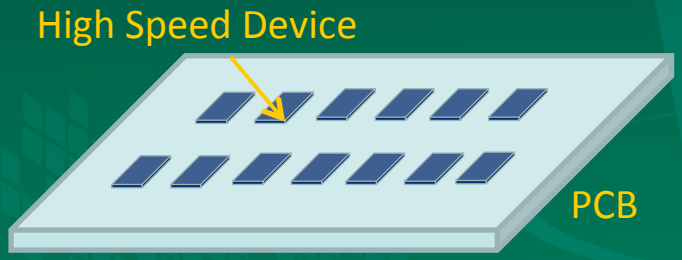
1. Technical trend of High Speed PCB

Technical trend for testing

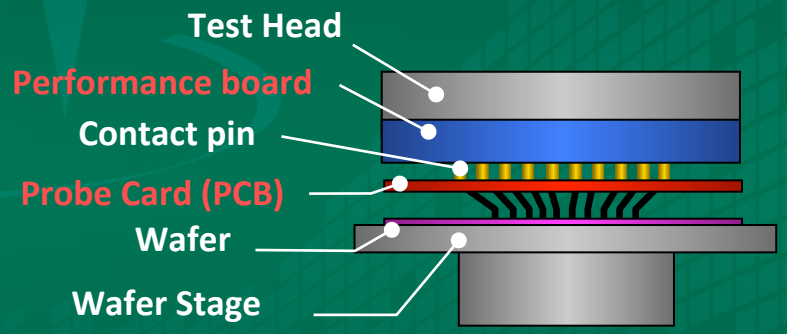
Infrastructures (Server/Network)

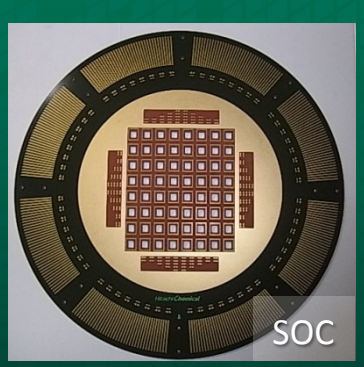
- High data rate : 25Gbps (2014-2015)
- (Target Loss -0.5dB / inch @ 12.5GHz)

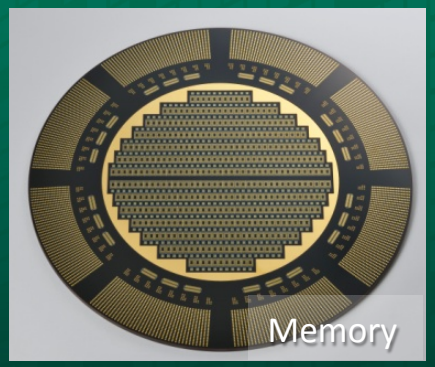


Wafer Testing

- Short testing time
- High data rate *SEAJ
  : 5.8Gbps(2016), 12.6Gbps(2020)



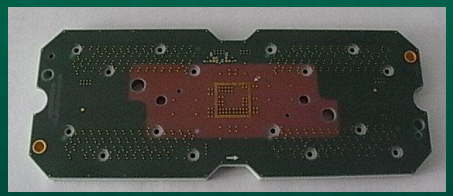




Package Testing

- High speed device
- High data rate *SEAJ
  : 20MT/s (2016), 40MT/s (2020)

Performance board
BIB (Burn-In-Board)
Socket board



PCB Technical Trend for Testing

Testing	Application	PCB Trend
Wafer	Probe Card • DRAM • CMOS, SOC Performance Board	• Larger • Thicker (High Layer Count) • Increasing Nets (DUTs) • High Frequency
Package	Performance Board (Interface Board) Socket Board Burn-in Board	• Larger • Thicker (High Layer Count) • Tight Pin Pitch, HDI • High Frequency

Technology for high frequency application

High Speed

- Lower dielectric loss
  - Lower Dk, Df material
- Lower Conductive Resistance
  - Wider/Thicker Cu trace
  - Lower Profile Cu trace (Less Roughness)

Routing Densities

- Tight Pin and Via Pitch
  - Smaller via
  - HDI (Narrow Cu trace)
- Nets Increased
  - HDI (Narrow Cu trace)
- Electrical performance
  - Stable Zo control
  - Pair drive routing

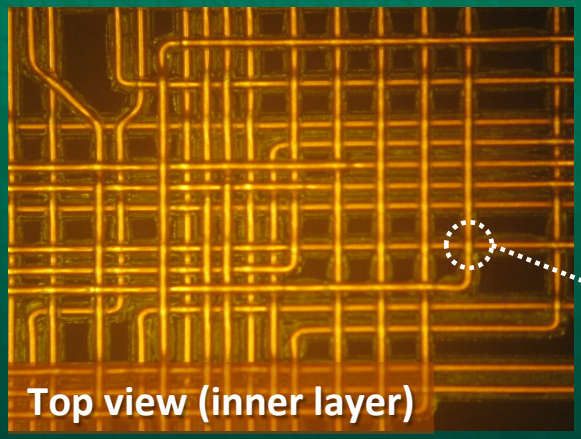
Confliction

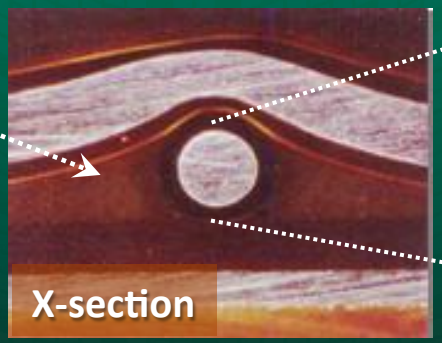
What is the best solution ???

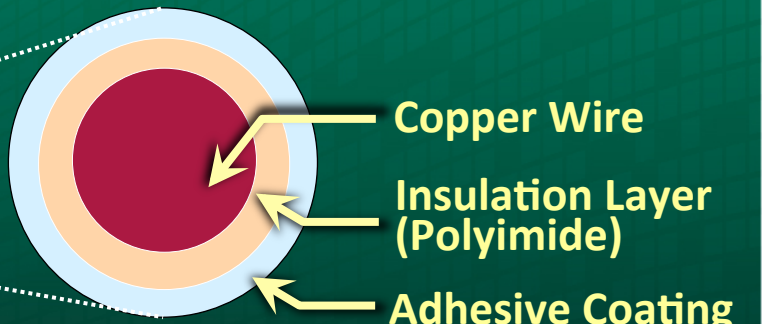
2. MWB technology

Multi-Wire-Board ~ PCB technology

- MWB is a PCB which replaces etched signal traces with copper wires on inner layers.
- Signal lines are able to cross over each other because of insulated copper wire.
- Achieved >25k nets routing (> 1,000DUTs) for Probe Card PCB







MWB Process Flow

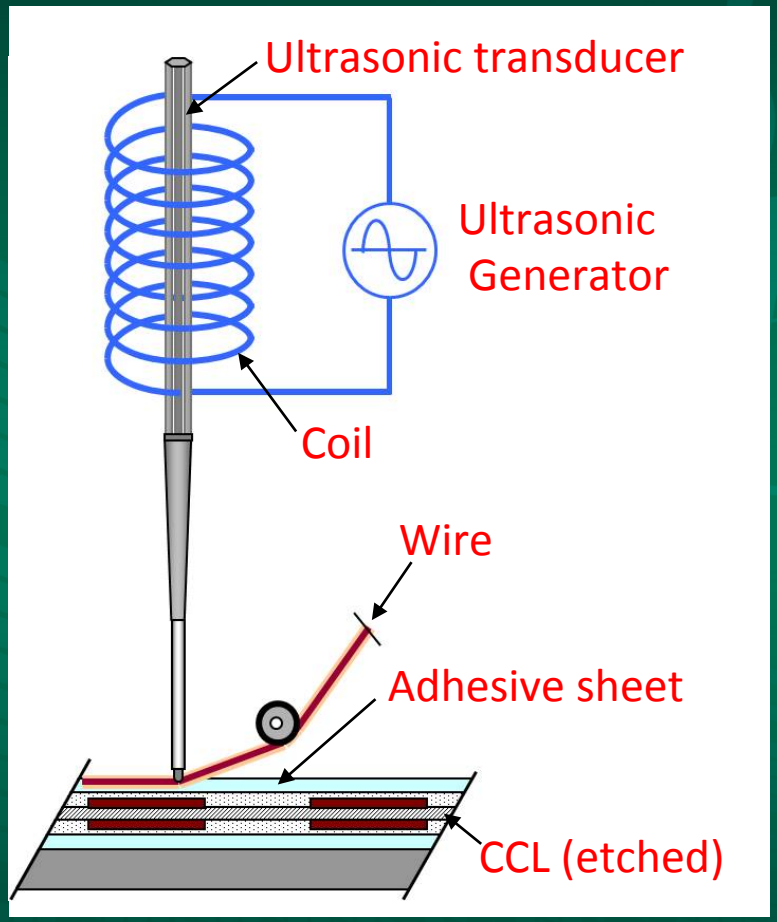
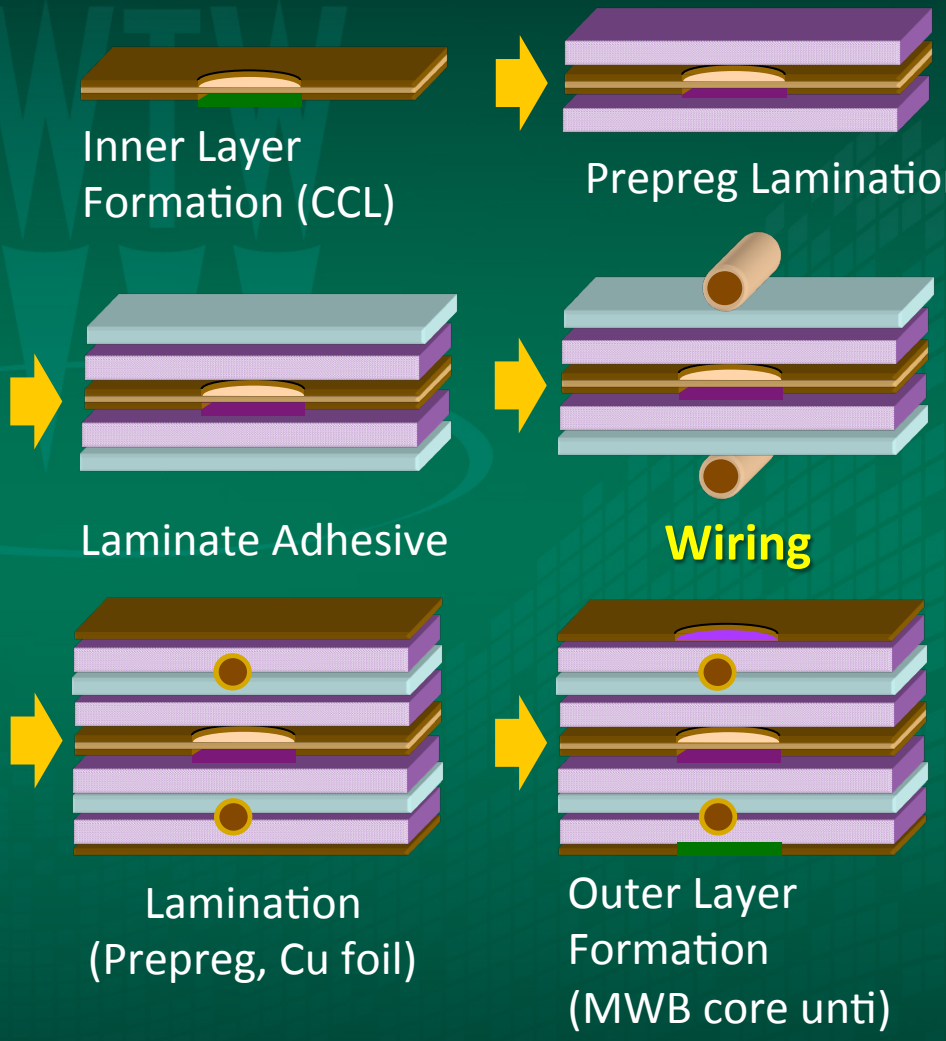
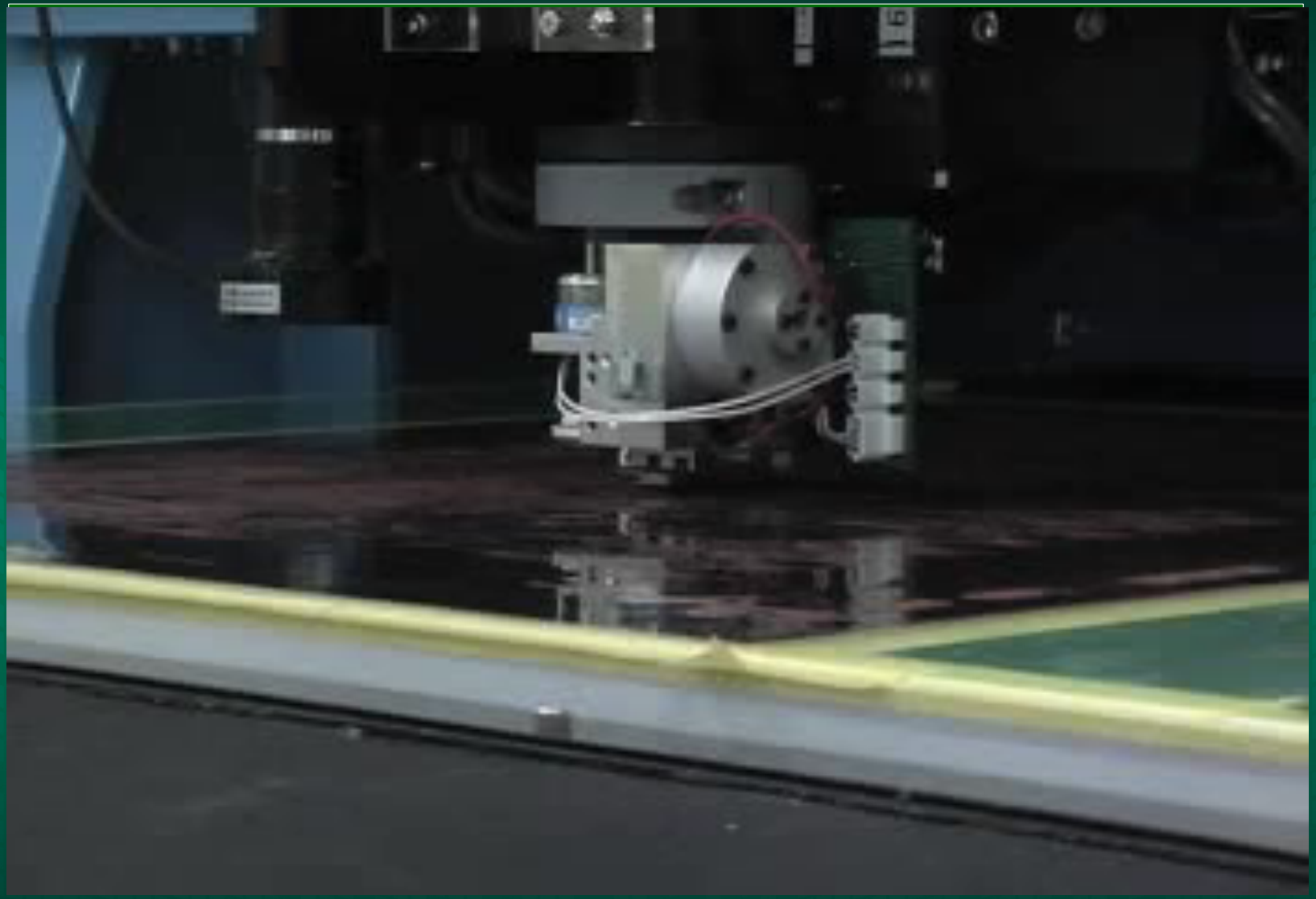


Image of wiring



Manufacturing Flow

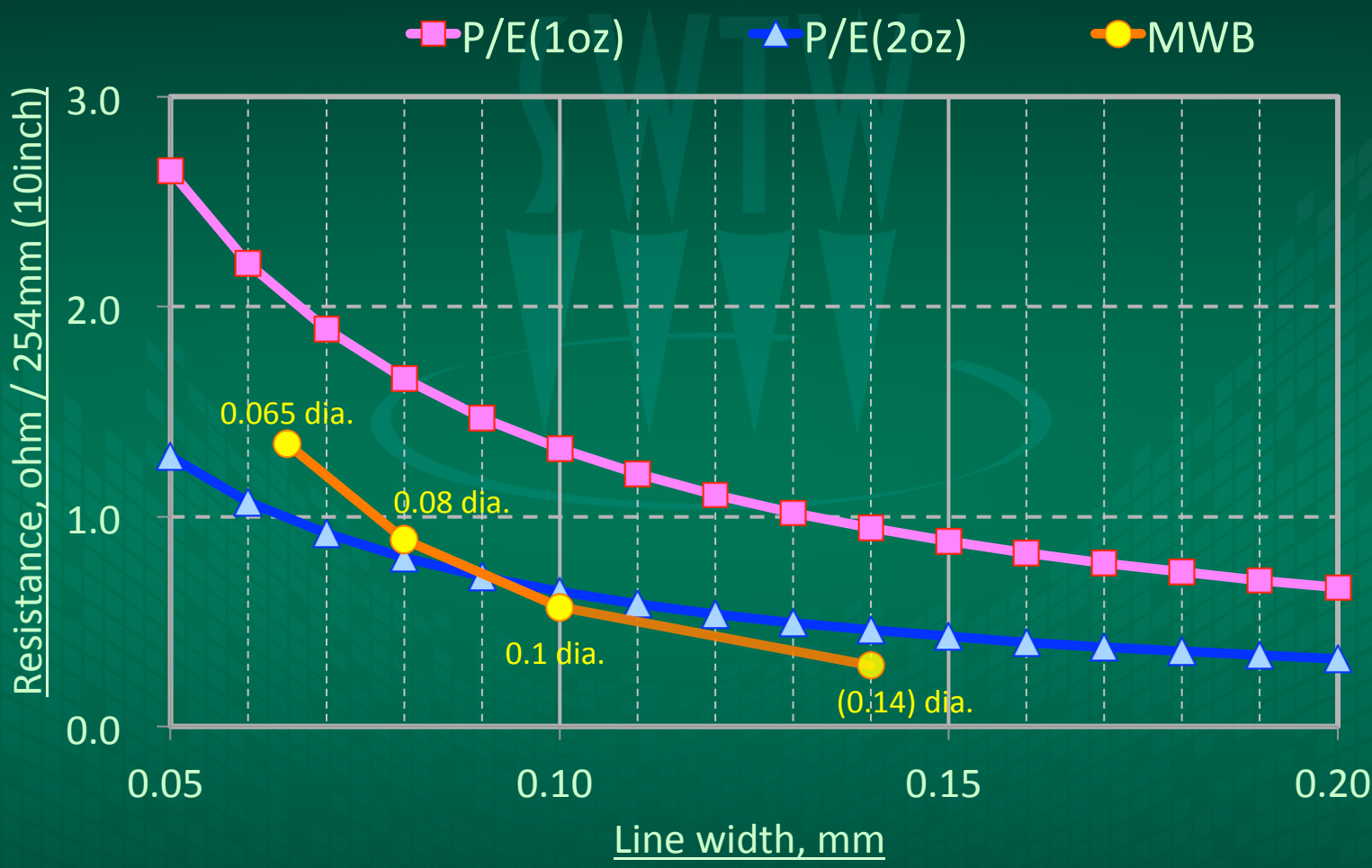
Wiring Image



Capability of MWB

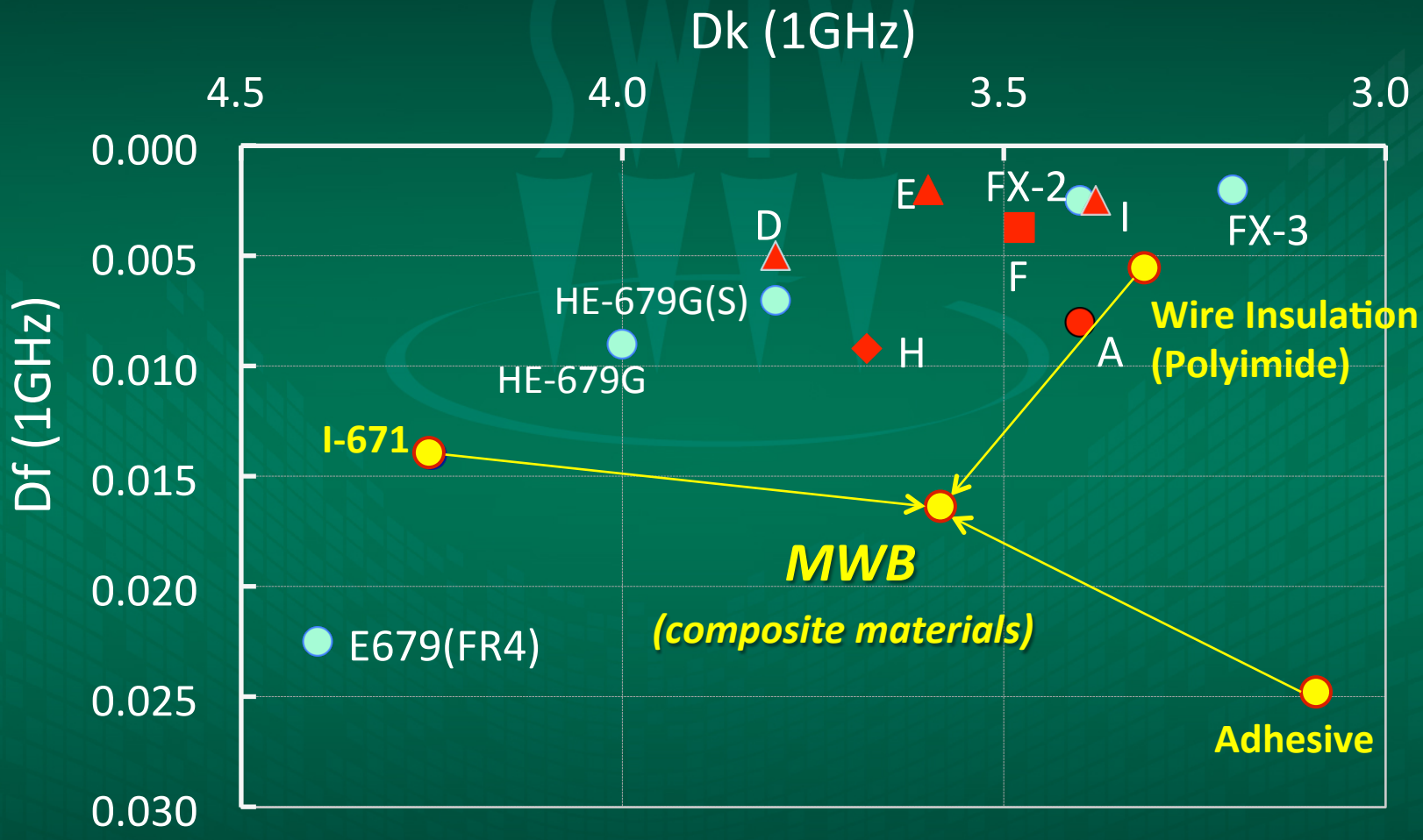
Item	Unit	Capability	Note
Size	mm	700 x 560	-
Thickness	mm	7.4	-
Wire diameter (Cu dia.)	mm	0.065 0.080 0.100	-
Raw Material (CCL, Prepreg)	-	High Temp. FR4 Polyimide Mid & Low Loss	E679 I671 (Std. for MWB) HE679G, FX-2
Routing Density (Trace / PTH pitch)	Wire / mm	1 wire / 0.65 2 wire / 0.80	-
Routing Density	# of Net / Layer	1,500 2,500	Probe Card Mother Board

Signal Line Resistance of MWB



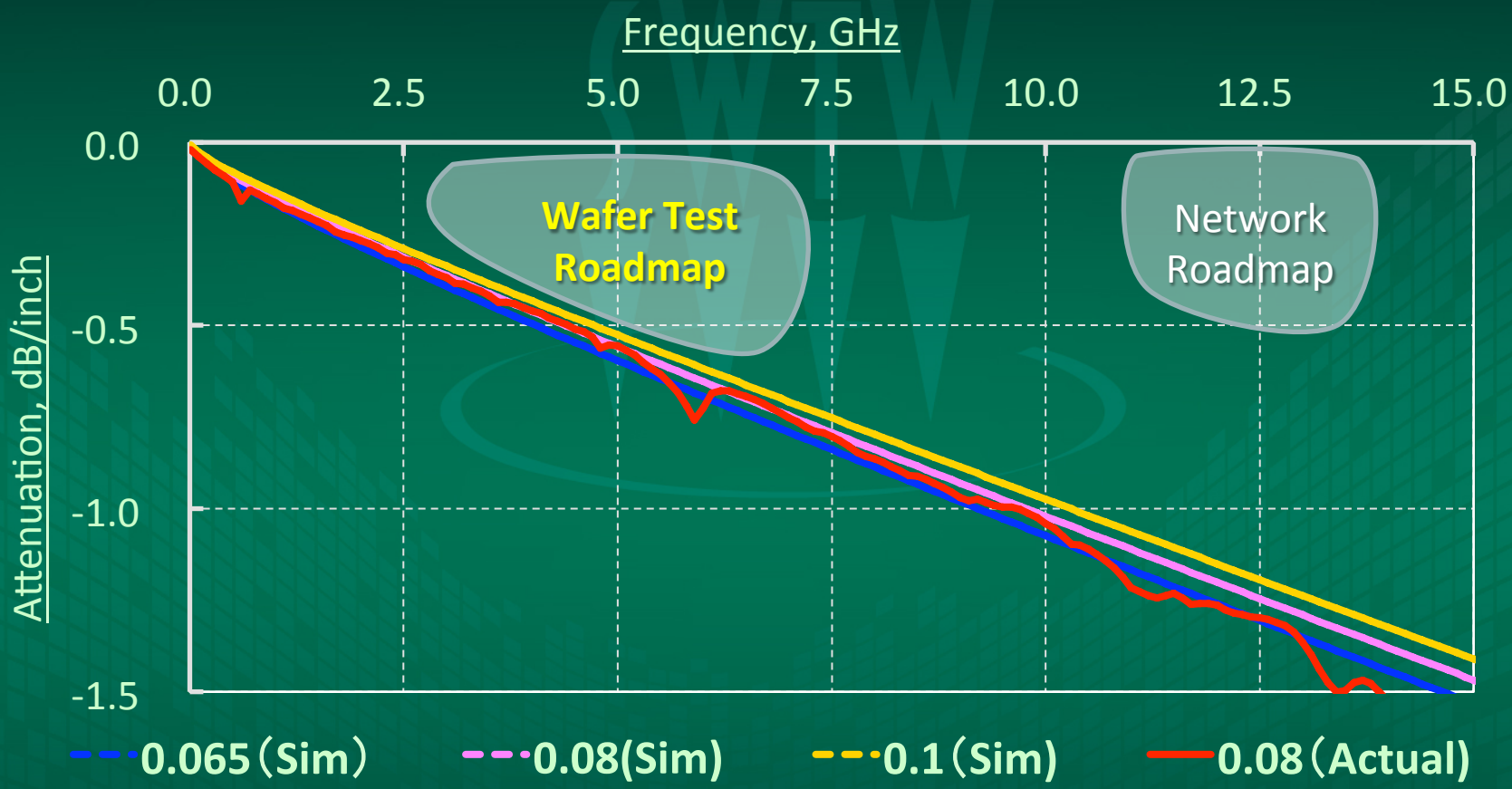
Wire for MWB has quite low resistance if compared with 1oz, and lower than 2oz, if dia. is > 0.1mm

Material Character (Dk, Df) of MWB



Dk and Df of MWB are higher than Low loss materials

Signal Attenuation of MWB



At current Dk & Df values, MWB falls short of meeting upcoming high speed requirements in the range of 3GHz ~.

MWB technology for High Speed Application

- HCC is able to support high density PCB requirements with our MWB technology by addressing
  - High signal count by cross over wiring
  - Low signal resistance by using wires with wider cross section
- But, improvements are needed to meet next generation high speed requirements

To solve confliction b/w high speed and routing density, we start development of Low-Loss Multi-Wire technology.

3. MWB developments for High Speed

What improvements required ?

Board design for High Frequency

Conductor loss

Wire design

- Shortest wiring
- Wiring angle
- Wider wire
- Low wire surface roughness

PTH design

- Stub-less (Back drilling)
- Zo accuracy

Dielectric loss

Raw Material

- Low Dk, Df material

Coating Mtl. of wire

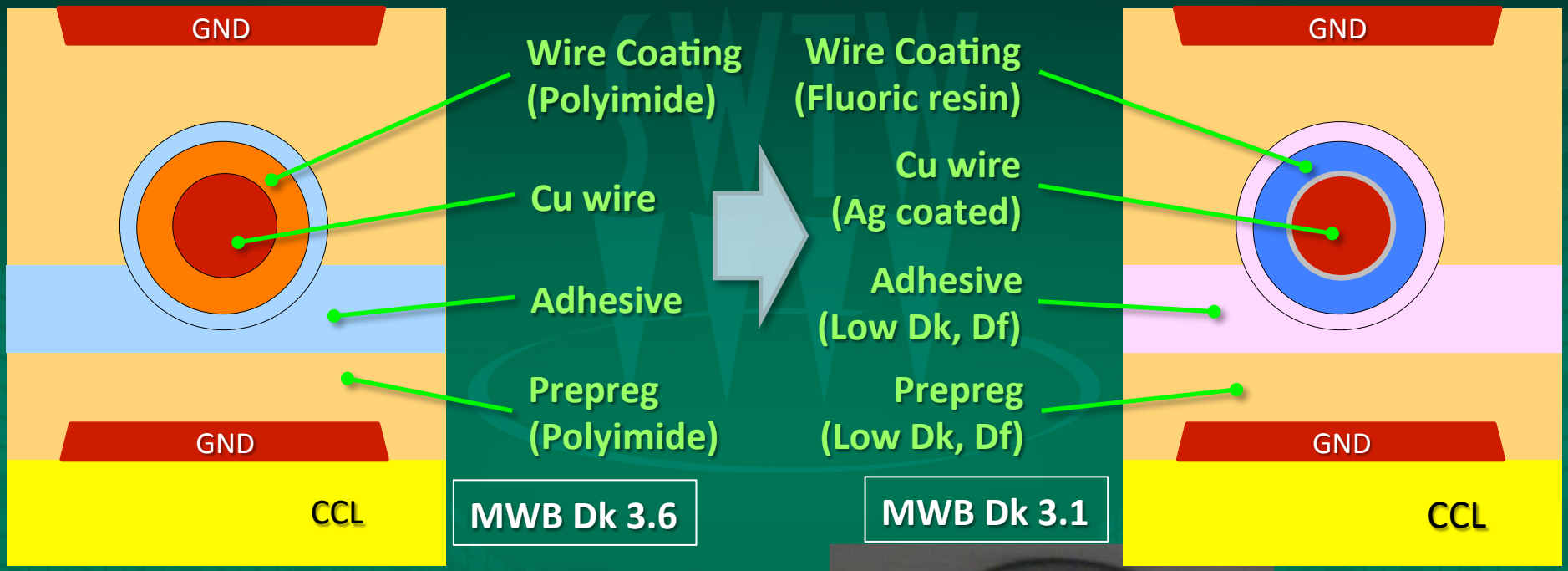
- Low Dk, Df material

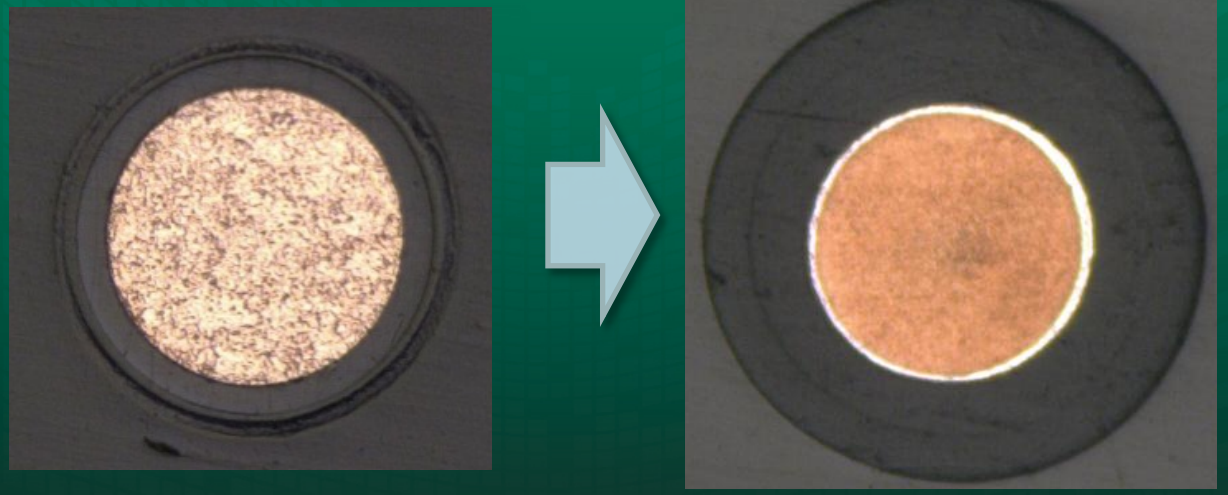
We study Low Loss MW with changing of Wire design, Raw materials, and Wire coating material.

Development of High Speed MWB

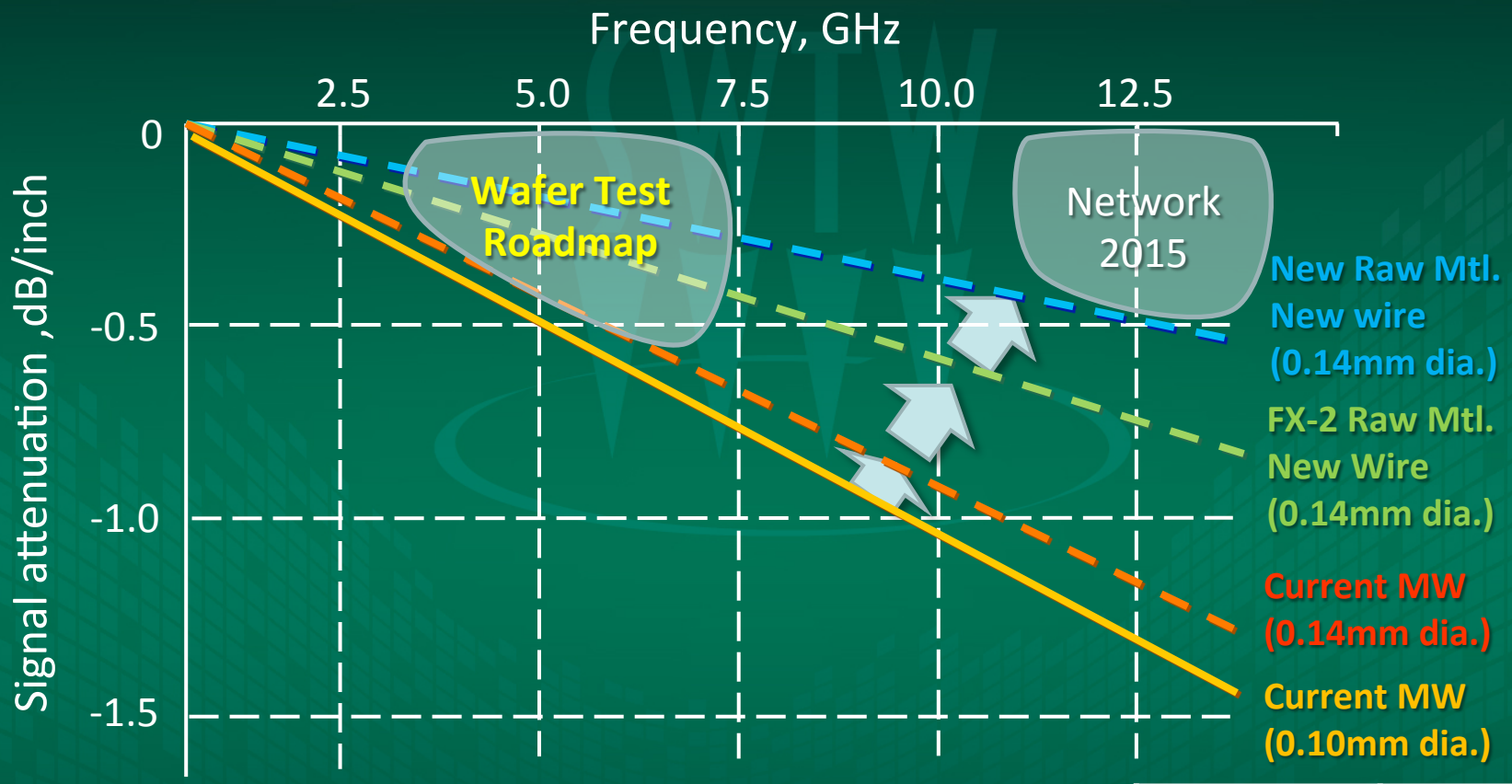
Item		Current	Development
Conductor	Wire Diameter	0.1mm max.	0.14mm
	Low Profile	Cu wire 0.3um roughness	Cu wire ≤ 0.2um roughness
Dielectric	Raw Material	I671 Polyimide Dk 4.3, Df 0.014	New Mtl. Hydrocarbon Dk 3.3, Df 0.0023
	Adhesive	Type-A Dk 3.1, Df 0.025	Type-B Dk 3.0, Df 0.018
	Wire Coating	Polyimide Dk 3.35, Df 0.006	Fluoric Resin Dk 2.6, Df 0.001

Stack up comparison





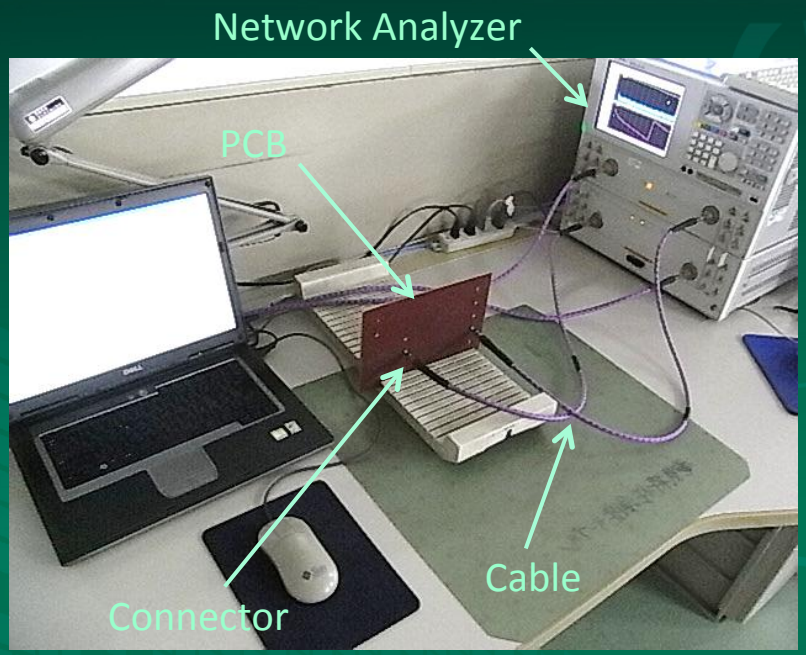
Simulation of signal attenuations



Regarding simulation, we estimate MW can achieve target loss with changing wire and materials.

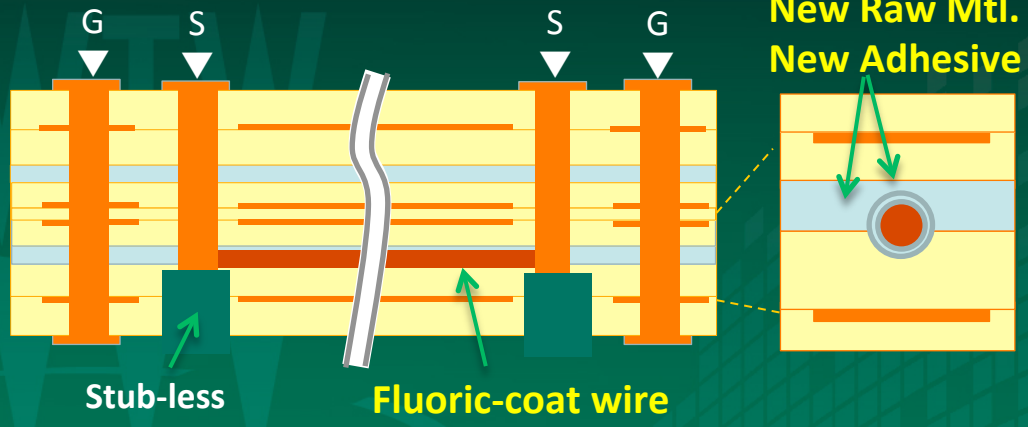
Raw Material	Dk	Df
New Mtl.	3.3	0.0023
FX-2 (low loss)	3.4	0.0025
Current (PI)	4.25	0.014

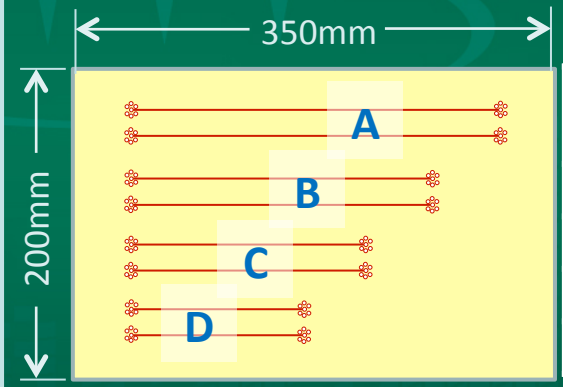
Sample Evaluation



Measurement conditions

- Network Analyzer : Agilent E8363B
- S-parameter Test Set : Agilent N4420B
- Frequency Range : 0.01 ~ 15 GHz
- Connector : SMA





Pattern	Wire dia. (mm)	Length (mm)
A	0.14	304
B		254
C		177
D		127

Evaluation board

- Fluoric-coated, 0.14mm new wire
- New raw, adhesive materials
- PTH Stub-less with Back-Drilling, Zo controlled
- Impedance 50ohm targeted
- 4 types of length

Measurement Results

Item		Unit	PI-MW (0.14mm) Simulation	Low-Loss MW	
				Simulation	Result
Impedance (Zo)		Ω	(at 50)	50	53.8
Tpd		ns/m	6.4	5.9	5.7
Dk (Cal. from Tpd)		-	3.6	3.1	2.95
Attenuation	@ 1GHz	dB/inch	-0.1	-0.04	-0.09
	@ 3GHz		-0.31	-0.12	-0.18
	@ 5GHz		-0.52	-0.2	-0.27
	@ 7GHz		-0.73	-0.28	-0.36
	@ 12.5GHz		-1.3	-0.5	-0.59

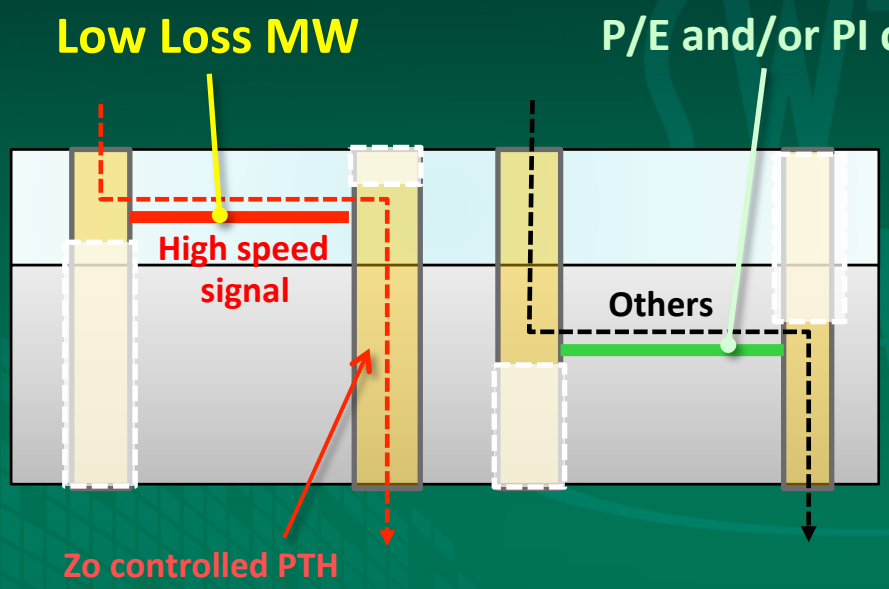
Average values of sample A ~ D

Tpd improved 12%

Dk improved 18% **(Df to be reviewed)**

Signal Attenuation improved around 50%

Concept of Low Loss MWB



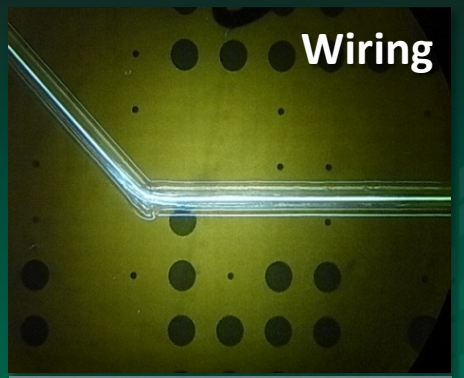
Advanced MWB

- Hybrid of Low Loss Mtl. portion and Standard Mtl. portion
- Hybrid of Low Loss MW and Current MW
- Hybrid of MW and P/E

Multiple constructions will be available to accommodate a wider range of performance and cost requirements

Future Development

- Development of PCB manufacturing technologies
  - Wiring design and conditions
  - Lamination press for composited materials
  - Drilling and Cu plating
- Evaluation of Reliabilities
  - Interconnection reliability for wire and PTH
  - Reflow resistance with composited materials
- Evaluation of electrical performance
  - Differential pair signal performance
  - Affection of crossover wiring
  - Zo control of wire and PTH



Summary

- To meet the upcoming demands of increased device speeds, Hitachi Chemical is developing a Low Loss Multi-Wire as an higher performance alternative to our current Multi-Wire.
- With this advanced structure, Dk values are improved from 3.6 to 2.95, with attenuation loss from -0.52 to -0.27 dB/inch at 5Ghz, and -1.3 to -0.59dB/inch at 12.5GHz

With the development of our Low-Loss MWB, we aim to support our customers across different platforms with the technology performance to meet demanding requirements for speed and density.

Thank You!